Significance of Balanced Fertilization Based on Long-Term Fertilizer Experiments

By Lin Bao

Balanced fertilization is the key to efficient fertilizer utilization and for sustainable high yields. Long-term experiments demonstrate that utilization of nitrogen (N) alone, or N and phosphorus (P) created deficiencies of potassium (K) that can only be overcome by application of K fertilizers. Attention must also be given to other essential nutrients as well as the use of manures. It is possible for China to become self-sufficient in N and P fertilizers, but highly unlikely that this will be achieved for K in the foreseeable future.

Balanced fertilization is the key to efficient fertilizer utilization for sustainable high yields. Although dramatic increases in N, P and K fertilizer consumption has taken place in China, the use of P and K fertilizers is low compared to N. Also, it is important to note that secondary and micronutrient deficiencies are increasing. Research on balanced fertilization remains a high research priority because China must achieve efficient plant nutrient utilization in its agricultural production in order to accomplish its food and fiber production goals.

Results from 63 long-term (over 10 years) experiments on 10 soil types with various grain crops provide important information, as shown in Table 1. The contribution to yield from inorganic fertilizers averaged 46.3 percent with the average for rice 40 percent, summer corn 50 percent, winter wheat 60 percent and about 35 percent on certain monocrops.

Table 1. Contribution of fertilizers to crop yield (10-year average, percent).

Cropping patterns, %	No. of trials	Type of soil		Contribution to yield, %	10-year CV
Double rice/year	22	Paddy soil	Early rice	39.8	6.5
			Late rice	40.1	7.4
Paddy-dryland crops/year	14	Yellow-brown soil	Paddy	37.9	4.2
		Purple soil	Dryland crop	59.9	15.2
Two dryland crops/year	15	Chao soil	Wheat	62.7	15.7
		Drab soil	Maize	49.3	13.3
One dryland crop year	12	Black soil anthropogenic-alluvial soil	Dryland crop	34.6	9.5
Average				46.3	8.0

Table 2. Nutrient balance sheet, kg/ha in a total of 20 cropping seasons. (Zhengzhou, Henan, 1981-1990)

Treatment	Input, kg/ha			Output, kg/ha			Balance, kg/ha		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
CK	0	0	0	838	531	1,155	-838	-531	-1,155
N	2,400	0	0	2,115	873	2,085	285	-873	-2,085
NP	2,400	1,200	0	2,259	1,108	2,481	141	92	-2,481
NPK	2,400	1,200	1,200	2,386	1,136	2,859	14	64	-1,659
M	736	660	840	1,206	742	1,670	-470	-82	-830
MN	3,136	660	840	2,388	1,178	2,505	748	-518	-1,665
MNP	3,136	1,860	840	2,535	1,302	2,751	602	558	-1,911
MNPK	3,136	1,860	2,040	2,544	1,270	3,260	592	590	-1,220

Nutrient rate of inorganic fertilizers (kg/ha each crop) : N,120;P_2O_5,60;K_2O,60.
Nutrient rate of organic fertilizer (kg/ha each crop):N,31;P_2O_5,33;K_2O,42.

In double rice cropping systems, applying N alone at first increased yields, but as P and K became deficient (mined from the soil), yields dropped rapidly. Addition of P and particularly K produced dramatic increases in yield. Generally, upland crops such as wheat had a greater response to P than to K. Corn, however, responded more to K than to P.

Comparing the NPK plant nutrient removal by 20 crops with fertilizer input over 10 years, a balance sheet was obtained. It indicated that N and P were in surplus, but K was in deficit (Table 2).

In short-term experiments, N fertilizer alone had a good effect. However, with time this proved to be a poor practice. High and stable yields can only be achieved and maintained when N, P and K are combined rationally. Furthermore, applying organic manure along with NPK fertilizer was beneficial because it supplemented P and K, added some secondary and micronutrients, and improved the physical and biological characteristics of the soil. Table 3 shows deficient areas and magnitude of use for secondary and micronutrients.

Even balanced NPK fertilizer use with organic manure is not enough if a secondary or micronutrient is missing.

During the period of 1984 to 1994, fertilizer use (plant nutrient basis) increased from 17.4 to 33.1 million tonnes, an increase of 90.5 percent. Because of increasing demand for

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Table 3. Deficient and application areas of secondary and micronutrients in China.

Nutrient	Critical level, mg/kg	Deficient area		Magnitude of use, million ha
		million ha	% of total arable land	
Zn	≤0.5	48.6	51	9.7
B	≤0.5	32.8	34	5.9
Mo	≤0.15	44.3	47	1.0
Mn	≤5.0	20.5	21	0.3
Cu	≤0.2	6.5	7	
Fe	≤4.5	4.7	5	0.5
Total		26.7	166	17.4
S	—	26.7	28	41*
Mg	—	5.5	6	9
Ca	—	28.0	30	50
Total		60.2	63	101

*Calculated based on application rate of superphosphate and calcium-magnesium phosphate.